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ABSTRACT

This overview of the role of microcomputers in public education covers the following topics: (1) the growth of microcomputers in schools; (2) the role of professional organizations and federal and state government agencies; (3) patterns of use in the schools, including instruction in computer science, instruction in traditional subject areas, and productivity skills; (4) implementation issues such as location, scheduling, access, integration into the curriculum, multi-use applications, and diversity in student and teacher experience; (5) impact on faculty roles and functions; (6) teacher training; and (7) software design, production, and evaluation. Two examples of approaches to computer use and a summary conclude the report. (30 references). (MES)

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Policy Paper No. 84-C2

ISSUES IN TRAINING TEACHERS TO USE MICROCOMPUTERS IN THE CLASSROOM: EXAMPLES FROM THE UNITED STATES

Robert D. Hess
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February 1984

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The Stanford Education Policy Institute (SEPI) conducts research on current and emerging concerns in education policy. SEPI strives to produce timely reports responsive to the needs of policymakers, practitioners, scholars and other members of the education policy community. Present work focuses on four critical areas:

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Abstract

Educational use of computers in the United States is greatly diversified, in part because the press for using microcomputers was initially a grass-roots movement. Growth has been rapid: 19 percent of schools had microcomputers in 1981; and about 75 percent have them now. This paper argues that despite this growth, use has been unequally distributed across SES and gender lines. Three emerging uses are discussed: instruction in computer science (programming and hardware), instruction in traditional subject areas, and productivity skills (word processing, spread sheets, graphics). Implementation is through computer labs, microcomputers on carts, microcomputers in classrooms, and mobile labs. Major problems that were found include teacher training, quality of software, access to machines, procedures for integrating courseware into the curriculum, and equity of student use by SES, gender, and ethnic background. The paper concludes that successful implementation is linked to the nature of the existing organization, and to use of deliberate, careful procedures for introducing teachers to new technology.

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Issues in Training Teachers to Use Microcomputers in the Classroom: Examples from the United States

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1. Introduction

The dominant theme of microcomputer use in the United States is diversity. Roughly a third of the schools in this country have no microcomputers at the present time; many have only one or two machines; others have computer labs equipped to serve an entire class. In some schools with computers, any contact with the micro is optional; others require that students learn fundamentals of programming as a prerequisite for graduation. In some schools, the predominant use is for drill-and-practice; in others, instructors are teaching PASCAL; still others use micros for writing or accounting.

Three circumstances contributed to this diversity. First, educational governance in this country is decentralized, giving a great deal of autonomy to local districts and schools on matters that affect curriculum. Second, microcomputers rapidly achieved visibility and popularity with the public and a belief arose that computers would have a pervasive effect on society. Third, there was no centralized policy to constrain the choice of equipment or the use that was to be made of micros in instances where schools decided to acquire them. These factors gave rise to a "grass-roots" movement during which micros were acquired as a result of the interest and urging of students, parents, and teachers rather

than as an innovation adopted by educational authorities. Local autonomy and the appeal of micros thus combined to create a wide spectrum of use in the schools.

Such flexibility in implementation has disadvantages, but it may also have long term benefits. Decentralized authority can stimulate imaginative solutions to problems involved in bringing the new educational technologies into the schools, and these creative applications may offer useful models for others (Cohen, 1983). On the other hand, without institutional support, isolated local efforts may not be recognized and imaginative solutions may not become established.

This chapter offers an overview of the role that microcomputers now play in public education in the United States. Although some information is included to indicate national trends, the purpose of the chapter is to identify issues linked to implementation and training and to describe some of the solutions that schools have developed to make the new technology useful. The material is thus often illustrative, drawing particularly from patterns of use in several schools in the State of California, but also selecting examples of the experience of districts in other states.

The chapter does not cover the use of CAI programs with mainframe computers (Suppes, 1979) or the evaluations of such programs (Kulik, Bangert, & Williams, 1983). Neither does it attempt to trace the history of the introduction of computers into public education nor (unfortunately) can we acknowledge the contribution of pioneers in the field. The material included covers only a small part of the activities now underway in this

rapidly changing field. Our purpose is to identify issues and proposed solutions and to illustrate patterns of use rather than to describe them in a comprehensive fashion.

2. A Summary of the growth of micros in schools

Because individual teachers are often involved in the initial steps to acquire microcomputers, the new technology begins to alter the roles and attitudes of teachers even before machines are delivered to the school. The acquisition process is thus a useful background against which to describe the roles of teachers.

2.1. Emerging roles: Acquiring the first micros

Microcomputers are brought into the schools in the United States through several different routes. In the first few years after micros were developed, the most common path was through the enthusiasm of individual teachers and parents. The experience of a high school science teacher in Montana is an example of the effectiveness of individual faculty members. He attended a class on microcomputers given by the district with support from the National Science Foundation (a federal research funding agency), then developed some classroom applications on his own. The following summer, he and the principal of the high school attended an institute given by the local university. The two stayed up late every night working on a microcomputer that they had borrowed from a student in the high school. By the time the three-week institute was over, they had gained some competence with micros and had discussed plans for getting computers for the school. Since the high level of unemployment in the district precluded a request for a tax increase, they met with the school board and

community members and prepared a proposal for federal funds. It brought them $13,000 for the purchase of micros.

In another district, a math teacher bought his own micro and held after-school sessions for students who wanted to build micros from kits. They rented out these machines to obtain money to buy more kits. Students encouraged teachers to attend the after-school sessions, and it was through these efforts that the school and district staff became interested and began to look for ways to purchase computers.

Parents have played an important role in the growth of technology in the schools. Motivated by the belief that their children will be involved with technology in their careers and lives, they often urged the schools to acquire machines. They supported this pressure with activities to raise funds for purchasing machines to get things started. In one district in California, parents provided most of the funds to purchase micros during the first three years of their program. Typically, parents stimulate interest in getting a micro or in getting additional computers; they are not usually involved in choice of micros or the number to be acquired. They also frequently request workshops or training sessions for themselves in order to understand how the machines are used in classrooms.

In some instances, particularly after the potential usefulness of micros received publicity, computers were also introduced in a topdown fashion, with administrators taking the lead (Cunningham, 1981). It was not unusual for parents to be involved in these decisions. For example, one district (in 1980) appointed a Community Computer Committee composed of community and

school staff, which recommended that they purchase ten microcomputers for use in several elementary schools and one junior high school. Inservice training for teachers and administrators was planned for the year; a limited amount of computer software was purchased for use at each of the schools. Such diversity of acquisition procedures has apparently widened the circle of those involved (students, parents, school personnel) and stimulated the development of innovative methods for implementing micros in the instructional life of the classroom.

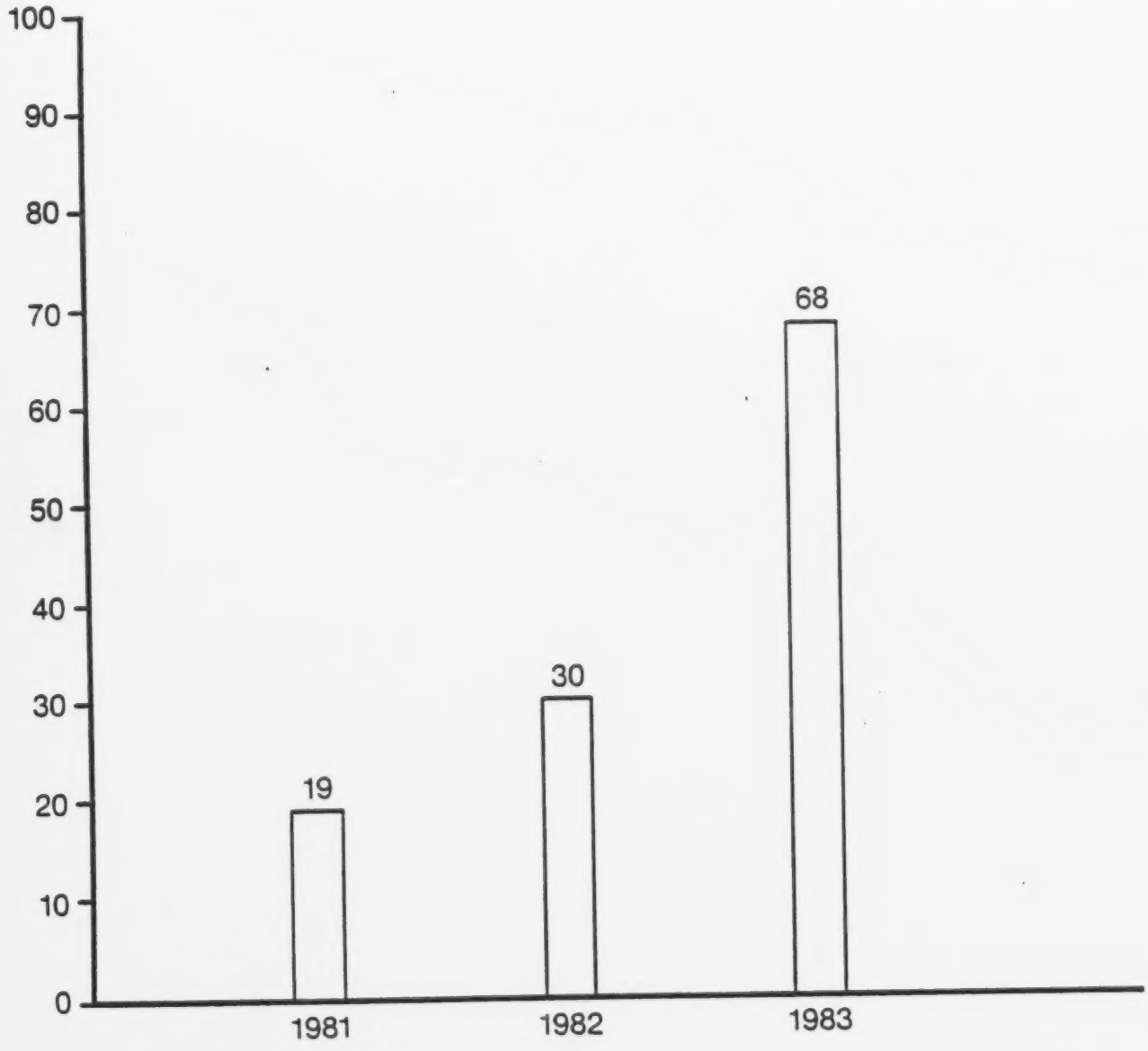
The routes of acquisition have changed in recent years. A survey carried out by the Center for Social Organization of Schools (CSOS) at Johns Hopkins University (Baltimore) indicates that prior to 1982, individual teachers most often played a central role; since that time, administrators have been more active in initiating first purchases of micros (CSOS, 1984). Up until the 1981-82 school year, in secondary schools, 47% of first purchases were strongly influenced by individual teachers. After that time, a single teacher was named as most important only 18% of the time in instances of first purchase of micros (CSOS, 1984). As we will note later, patterns of use in schools appear to be related to routes through which micros were acquired.

2.2. Growth rates over recent years

The growth of micros in the schools has been dramatic, especially considering the fact that it was a grass-roots activity. In 1981, there were approximately 200,000 micros in the public schools; by 1983, this number had increased to 325,000 (MDR, 1983). There is little reason to expect that the rate of

Figure 1

Percent of all public schools in the United States that have at least one microcomputer, 1981-1983



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growth will level off in the near future, but continued increase in the long term may depend on several factors that we will discuss later. The overall increase in number of microcomputers is indicated by the proportion of schools that had at least one machine in the years 1981 to 1983 (Figure 1). A majority (68%) of schools, including all categories of secondary schools (urban, suburban or rural; low-income or high-income students; minority or white; public or private; large or small) had at least one microcomputer by October, 1983. Only at the elementary level were there groups of schools in which less than half had micros (CSOS, 1983c). Despite this rapid growth, the number of computers in each school is still relatively small. In secondary schools that have computers, the typical school has five micros.

2.3. Microcomputer use by type of school

The use of computers varies by type of school. They are more widely used in junior high schools (grades 7 - 9) and in secondary schools (grades 9 or 10 - 12) than in elementary schools. Secondary schools are also acquiring micros at a faster rate (Figure 2) (CSOS, 1983b).

2.4. Distribution by socioeconomic background and gender

Because the microcomputer was introduced into many schools through the enthusiasm of students or their parents, the early phases of micro acquisition followed occupational and socioeconomic lines. Parents who worked in occupations that utilize computer technology were more likely to stimulate their children's interest in micros and more likely to suggest to the school authorities that microcomputers be acquired for student use. Despite the considerable concern in the United States over

Growth of use of microcomputers in schools in the United States, by school type

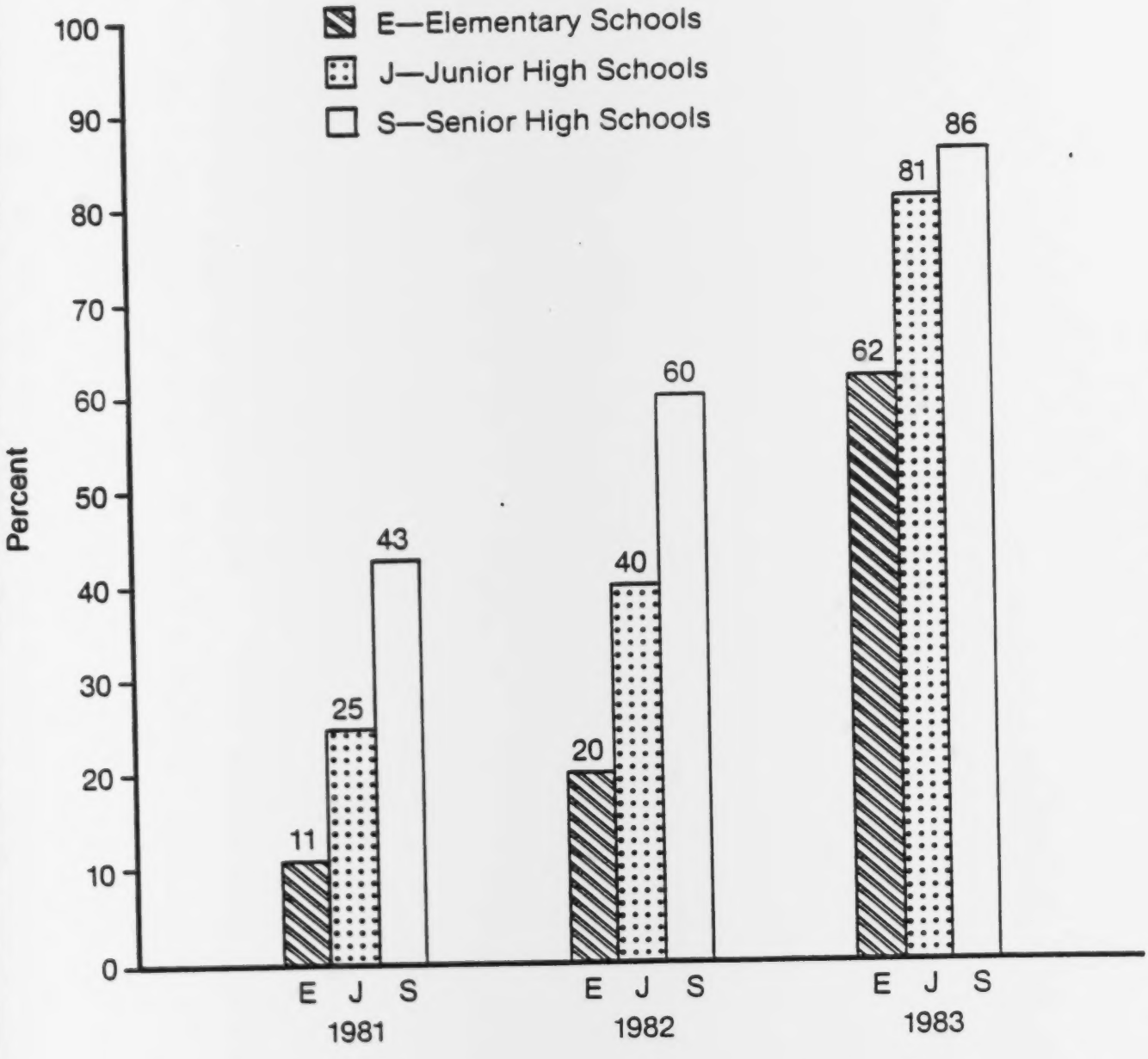
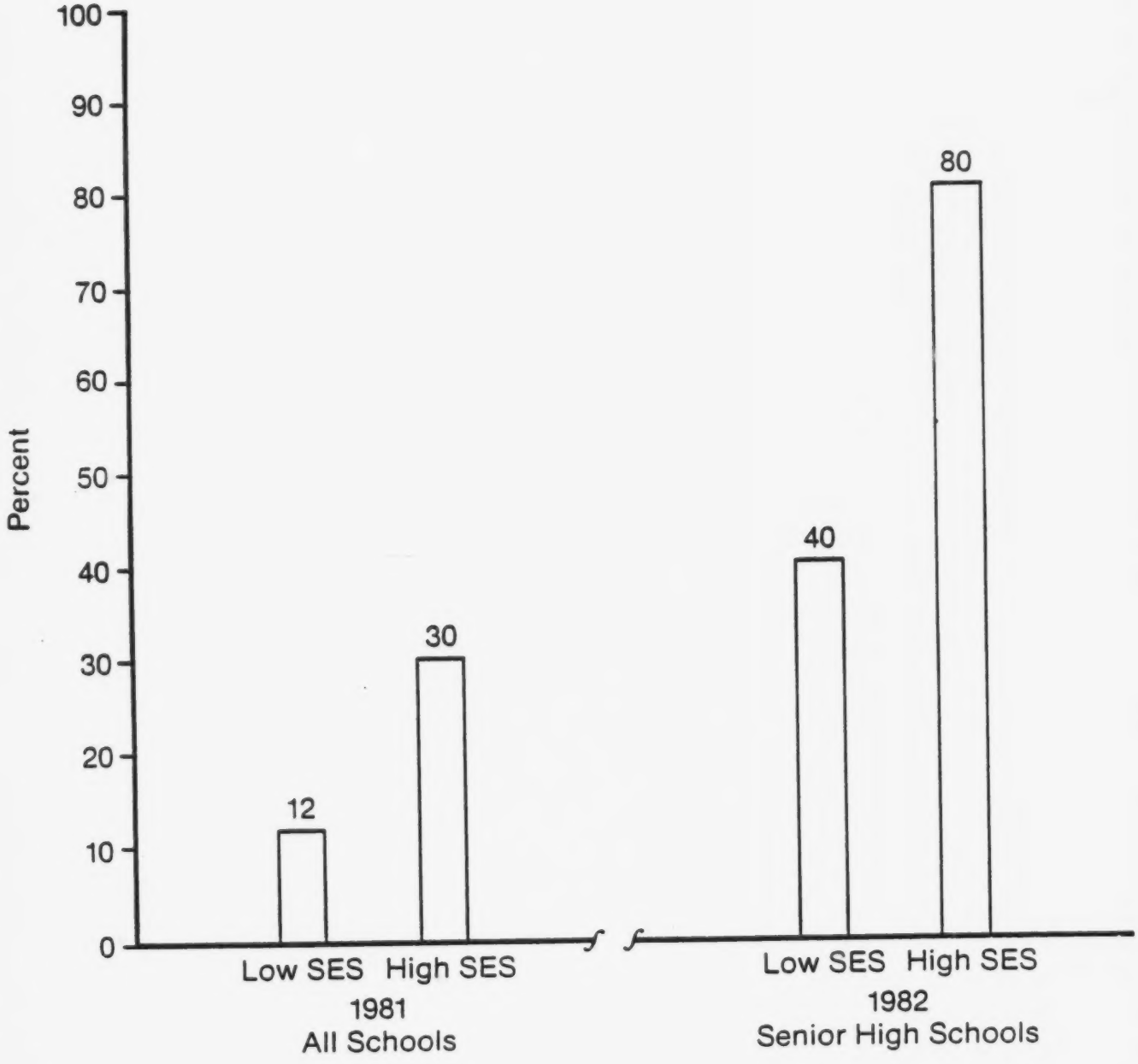


Figure 1

Percent of schools in the United States that have at least one microcomputer, by socioeconomic status (SES) of schools



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issues of equity and equal opportunity, these influences have created differential usage and access to computer training for students from different ethnic groups and socioeconomic (SES) levels (Figure 3) and for girls as well as boys. These SES differences in the schools are paralleled by differences in availability of computers at home, giving children from affluent backgrounds two advantages: they have access to equipment at school and after school they continue to use the new technology at home (Markoff, 1983; Wierzbicki, 1983).

There are also distinctions among Caucasian and ethnic "minority" schools in the use of micros even in low income schools. Schools that are predominantly Caucasian tend to introduce students to programming much more often than schools that serve minority students, which are more likely to emphasize drill-and-practice activities (CSOS, 1983c). In minority schools, often the first priority is to raise performance in essential subject areas, and micros are used to improve the skill of low achieving students. There is less opportunity for students in these schools to learn to program.

These differences in amount of time spent at computers between children from blue-collar and white-collar social backgrounds are paralleled by disparities in computer use by boys and girls, even in such out-of-school activities as computer camps (Hess & Miura, in press; Miura & Hess, 1984).

3. Role of organizations and governmental agencies

3.1. Professional organizations

Given the spontaneous character of the early growth of the

field, it is not surprising that leadership has come from groups of teachers and from a few pioneering individuals, who contributed through publications and, in some instances, by establishing training programs for teachers. Several professional organizations grew out of these informal networks and now have a major impact on the field (EL's second annual survey, 1982). One is the Minnesota Educational Computing Consortium (MECC), a cooperative venture begun in 1973. It now provides 435 districts in the State of Minnesota with access to a timeshare system, discounts on micros, a lending library of educational software, and inservice training for teachers. Membership in 1982 included all educational institutions in Minnesota and 77 out-of-state institutions from 34 different states, several Canadian provinces and foreign countries. MECC also offers administrative computing support, development and research on software for the major micros, software systems, and timesharing. MECC sponsors conferences, helps agencies evaluate software, and serves as a resource to many agencies and groups throughout the United States.

CUE--Computer Using Educators--was established in 1978 in the San Francisco Bay area. From a small group of 30 teachers who met to discuss ways to use micros in their classrooms, CUE has grown to a membership of more than 8,000. CUE sponsors conferences each year in the autumn and spring that attract participants and audience from throughout the United States. CUE also works with a Microcomputer Center located in a county office of education to facilitate exchange of software among teachers. It also acts as a resource for consultation with county and state offices that are considering training or funding programs. The

professionals who have provided leadership for MECC and CUE are also active as individuals, serving on commissions and committees at state and national levels to draft recommendations on credentialling and software standards, and they influence the field through consulting, lecturing and publishing. MECC, CUE, and other rapidly developing professional groups have a significant impact on the direction the field is taking.

3.2. The Federal role

Much of the activity to extend the use of micros in the schools takes place at the level of the school district. These activities are often supported by county offices of education and by state educational agencies, but there is less involvement at the federal level. The federal government has defined its role as one of encouraging dissemination of information, supporting research, and facilitating local effort. A quote from Dr. Donald J. Senese, Assistant Secretary, U. S. Department of Education, summarizes this view:

> Computers are part of a grassroots movement. No longer confined to homes and video game arcades, computers have successfully attracted the attention of the academic hierarchy--school boards, teachers, principals, superintendents, and State and federal educational officials. Programs which effectively utilize the potential of computers must develop at the local level, the result of teachers and students as well as educators and computer manufacturers working together. They must not and should not comprise a limited number of programs created at the federal level,

imposed on schools throughout the country. (Senese, 1983, p.99).

The United States Department of Education, however, announced a "Technology Initiative" on June 22, 1982, and organized an Education Task Force to examine major issues involved in implementing computer instruction in the classroom. Several programs, supported by Federal grants, offer training for local and state education officials. These include Project BEST (now the Association for Educational Communications and Technology) that works with more than 40 state agencies, providing information and electronic mail service, and fostering communication. Project SLATE (State Leadership Assistance for Technical Education) is involved with about 20 states to provide workshops for top level education officials, legislators, and staff. Project VIM (Videodisc Interactive Microcomputer) offers a network for communication among 45 individual school sites that use both videodiscs and microcomputers. The focus at the federal level is to facilitate flow of information to the state and local officials (Senese, 1983).

The United States Department of Education, through the Office of Educational Research and Improvement (OERI), also supports research and demonstration projects designed to address specific instructional needs. Project Quill uses microcomputer-based programs to help students in grades 3 to 6 to improve writing skills. The National Diffusion Network (NDN), a part of OERI, identifies and disseminates exemplary programs for replication in other school districts. NDN has identified outstanding schools utilizing technology as "lighthouse" schools. These sites

received funding to host visitors and to provide materials to facilitate the use of technology by schools. OERI also provides funds to its ten regional offices to help upgrade teacher skills in technology. At this point, these funds are limited--$100,000 to be spread among the ten regions for coordinating and facilitating activities.

3.3. Legislation at the state level

Even when innovations originate in the field, in order to survive, they eventually need support from the district and the state for technical assistance, funding for equipment, and staff training. A number of states are responding to activity at the local level (National Science Board, 1983). As early as 1981, most of the chief officers of the 50 states had conducted surveys to assess these needs and formulate possible solutions (Calkins, 1981). A survey by Electronic Learning (November/December, 1983), revealed that 26 states have created a position of computer education coordinator. The responsibility of this official is to oversee the continuing use of computers in schools for administrative and instructional purposes (Christen & Gladstone, 1983).

In California, a task force representing the State Department of Education coordinates the efforts of the Computer Education Unit, which is a branch of the Technology Division of the Department. It also coordinates activities of the Office of Staff Development (teacher training) and of other divisions involved in educational technology.

Fifteen state-funded Teacher Education and Computer Centers,

located throughout California were established in 1982. In cooperation with state universities, the TEC Centers offer in-service training for teachers in computer literacy, science, and mathematics.

3.3.1. Curriculum requirements

State legislatures have become aware of both the importance of technical training and the growing public interest in the use of microcomputers in schools. In many states, there is an ongoing debate about what legislation might be appropriate to facilitate the use of new technologies in schools (Christen & Gladstone, 1983).

As of late 1983, three states (Florida, Rhode Island, Virginia) and the District of Columbia have passed legislation that will require students (starting at a date ranging from one year to four years in the future) to demonstrate minimal computer skills before graduation from high school. Two additional states (Indiana, South Dakota), require districts to offer computer literacy courses, but students are not required to take such courses.

Twelve other states (Arkansas, Colorado, Delaware, Hawaii, Minnesota, Nevada, North Carolina, North Dakota--secondary schools, Ohio, Oregon, Pennsylvania, and Texas) officially "recommend" that schools offer computer courses but leave action to the discretion of the schools. Twenty-four states are currently considering similar proposals or proposals for requiring some form of computer literacy.

The requirements passed or considered by these states range in scope. Rhode Island, for example, has a high school graduation

requirement of one-half unit of work in "computer literacy"--a requirement that will undergo review in 1984. The common focus of this issue is the debate over the term "computer literacy." The general spirit of diversity and flexibility of choice that prevails in educational technology is illustrated most vividly by debates about computer literacy. Two issues are prominent: first, what is to be included in a course (or definition) of literacy, and second, should all students be expected to take coursework in this area (Educational Testing Service, 1983; Southeastern Regional Council for Educational Improvement, 1983).

These two issues are closely related. If computer literacy is defined to include instruction in programming, there is considerable opposition to making courses in computer literacy mandatory. There is, however, support for the concept that courses in programming should be available to students in the secondary schools and many believe that programming should be available to elementary school students as well. On the other hand, if computer literacy is defined as a general course in the use of computers in the society, there is support for making such courses mandatory.

3.3.2. Teacher training and certification

Even in states that do not specify curriculum requirements for students at the local level, state legislatures and departments of education sometimes establish standards for teacher certification and provide inducements for teachers to get inservice training in some aspect of educational technology.

By late 1983, 16 states either required or recommended pre-

or inservice training in educational uses of computers. An additional twenty states are considering proposals for such training. The goal of the State of Rhode Island, for example, is that 90% of all teachers will be "computer-aware" in three years, of which 40-50% will be "computer literate." Only Arkansas and the District of Columbia have passed legislation that requires teachers to gain competence with computers. Seven states require preservice training-- Arkansas, District of Columbia, Montana, New Hampshire (middle schools), South Dakota (for computer science teachers), Utah, and Vermont. The level of concern is highest about teachers who offer courses in programming and "computer science." It seems likely that certification requirements will soon emerge for training such teachers.

In California, in 1983, the Legislative School and Finance Reform Bill earmarked funds for the Department of Education for the development of comprehensive kindergarten through grade 12 (high school) computer studies curriculum, specifying skills students are expected to acquire at each grade level. It is expected that an advisory panel will present, early in 1984, pre-service recommendations to the Commission on Teacher Education, the group that establishes standards for credentialling teachers in the State.

3.3.3. Funds for curriculum development and training

At this time, funding for both training and equipment comes from a variety of sources--parent groups, especially at the elementary school level (CSOS, 1984), gifts from foundations, equipment and software from corporations (Mace, 1983), and reallocation of district funds to purchase micros. Some funds are

provided by states for training and equipment and for demonstration programs that offer examples, collegial support, information, and technical assistance. At least ten states and the District of Columbia each devote over a million dollars to equipment and training (Christen & Gladstone, 1983). At the state level, emphasis is more on developing inservice training and networking capabilities.

The State of California provides financial assistance in two forms. One is through tax credit through a legislative act (the Imbrecht Bill) passed in 1982, that allows tax credit for micros donated by corporations to schools covering grades kindergarten through secondary school. Computer companies plan to provide more than 10,000 micros to schools in the state.

The State also supports inservice training through grants to school districts in collaboration with institutions of higher education. Funds available for this training were made available in the legislation of 1982. In July, 1983, legislation (SB813) was passed that targets funds for the development in 1984-85 of additional specialized high schools in "high technology." One such school is described later in this chapter.

This bill also requires the State Superintendent of Schools to develop a course of study in computer education. It is expected that in 1984 new guidelines will be developed for courses in science and mathematics to emphasize the use of computers.

4. Emerging patterns of use in the schools

Any analysis of the effects of computers on the functions and roles of instructional staff should recognize that there is little

agreement about the place that computers should have in the curriculum. The first uses of micros in schools followed the interests of the central actors who brought the machines to the school and decisions about use were often based on individual circumstances. A quote from an intensive study of six schools in the San Diego area gives one perspective:

> At present, diversity in computer use in schools is the rule rather than the exception. All the teachers interviewed described having freedom of choice concerning the form and content of computer classes. Most of the teachers knew their activities were different from classes at other schools but weren't bothered by the disparity. Moreover, everyone expressed interest in knowing more about other schools, looking for useful ideas to implement in their own classrooms. Even the secondary school with the most traditional approach (algebra, BASIC, FORTRAN) had just set up a new class with a different approach (more use of commercial software and much less programming). (Cohen, 1983, p.49).

Three functionally different patterns of use are emerging in both secondary and elementary schools. Two of these require training in technical skills for both teachers and students and are thus machine and software dependent; the other utilizes the machine in instructional or supplemental activities but requires relatively little technical training and experience, although the instructional activities are greatly enhanced by knowledge of operating systems and programming. The distinction is one of machine dependence--whether or not the subjects involved can be

taught without using computers. These three patterns are described briefly here and their implications discussed later.

4.1. Instruction in computer science

Technical instruction (usually involving programming, operation of utility programs, and information about hardware) is the central element in these courses. Programming and knowledge about computers have become, de facto, a subject matter area. In elementary schools in the United States, one third of the instructional time on micros is spent having students copy, write, and test computer programs. In secondary schools, programming and "computer literacy" activities occupy about two thirds of the instructional time (CSOS, 1983b). At this level, computing is becoming established as a subject matter area. Some sources estimate that 25,000 teachers are currently engaged in teaching programming or other technical skills in the public schools in the United States.

This new subject area is the province of a small number of the faculty of each school. The courses they offer are not only designed to produce programmers, but also to give students a detailed introduction to computers. One teacher says, "We don't expect our kids to become programmers, but we want them to learn to control the machine. We want them to feel comfortable with the machine, to be able to use it." For some students, however, such courses may be the beginning of careers in technology.

4.2. Productivity skills: Advanced applications

Some schools offer instruction in operating systems and/or applications software--e.g., use of graphics, music, art programs

and devices, word processing, business applications, such as spreadsheets for accounting, skills in networking and telecommunication for links to data bases outside the school or for communication with students in other schools, and occasionally linking computers to videotape or audiotape equipment. This type of instruction does not necessarily involve programming, although it may be taught in the same course that covers a programming language. Since these skills require instruction in operating micros and relatively complex software programs, they are machine dependent. Instruction requires the use of micros and interactive software.

At this point, students in elementary schools spend relatively little time using micros as productivity tools (Cohen, 1983). In secondary schools such advanced applications account for a small proportion of student time on micros, probably less than 10%. Some individual schools, however, devote most of the instructional time on computers to these productivity skills (Cohen, 1983). Where these skills are taught, students tend to get more individual time on the machines, perhaps because these activities often involve relatively large assignments that take more time than typical drill-and-practice problems--writing an essay, doing an accounting problem, or creating a series of designs. These assignments cannot be as easily terminated and resumed later.

> Although relatively rare, students who use micros for editing and writing ('word processing'), or as a part of a science or electronics laboratory or in their business curriculum tend to get large chunks of time to use the

computer equipment. Typically, they get 30 minutes a week, which is half of what a programming student gets, but twice as much as what is given to students using the equipment for drill-and-practice. (CSOS, 1983b, p. 6).

4.3. Use of micros in classroom instruction

This type of use includes drill-and-practice, simulations, games, and other software intended to teach material that has traditionally been taught without the machine. To that degree, it is not dependent on new technology. New technology is used, presumably, because it may make such traditional instruction more efficient and free the teacher for more individualized work with students. Although the micro is the tool of instruction, relatively little technical skill is required of the teacher other than to turn the machine on and off, load disks, call programs, and follow the directions on the screen.

Recent surveys (CSOS, 1983b) indicate that in the elementary schools that have computers, 40% of all instructional time is spent by students who use computer programs for practicing mathematics and language facts, spelling drills, and various other memorization tasks. In secondary schools, drill-and-practice activities take up about 18% of the time spent on micros. Since two thirds of the computer time is taken up with programming-related skills, this means that in secondary schools, students do not use micros primarily to develop intellectual skills in traditional subject areas.

Micros are also sometimes made available for individual student use. These activities include games, using the computer

as a reward for performance in non-computer activities, and self-help remediation in courses for which drill-and-practice programs are available. An example illustrates this practice.

> The math approach (at Plains High School) was to put some machines in the back of the classroom to be used for enrichment and remediation. The class would be taught normally, but if students finished class assignments, they could use the microcomputers for enrichment. Students having problems with the material could use the microcomputers for remediation.

About one-fifth of the time students in elementary schools spend on micros is spent playing games under the supervision of the teacher (CSOS, 1983b). Apparently, many of these games are intended to provide drill-and-practice in educational skills. A smaller proportion of time in secondary schools is taken up with games (CSOS, 1983b).

4.4. Summary

The implications of introducing micros into the schools depend on how these three patterns of computer use grow in the future. Significant growth in instructional uses that are machine dependent--that is, instruction that cannot be carried out without software and micros--would have the most far-reaching impact on the field. So long as the teacher can turn to the mimeograph machine or the blackboard or a text to accomplish his or her instructional goals, the use of micros will be limited and the impact on teacher roles will be minimal.

There is thus a significant distinction between instruction

that requires the use of micros and instruction in which computers are used to facilitate the task of the teacher. It seems likely that students in subjects that require computers in order to develop a particular competence (programming, business) will get priority in their use. The Johns Hopkins survey, for example, indicates that secondary school students who are taking programming classes use micros for about an hour each week. Another group of secondary students gets somewhat lower priority: those who use the micros for what we call productivity skills (word processing, graphics, or spreadsheet work in business) typically get 30 minutes each week. On the other hand, students using micros for skills practice get about 17 minutes per week. The priority given to the machine is directly related to the degree to which students need to use the computer to master the skill involved and, possibly, the task demands of the activity itself.

There are indications that experience changes the attitudes of teachers about how computers should be used. In a survey of teachers who acquired micros before July, 1981, two thirds of secondary and one third of the elementary teachers who originally viewed the micro as a tool to help teach basic skills came to view it as a resource for students to learn more about computers. In contrast, only about 10% of those who initially thought of it as a resource now think of it as an educational tool (CSOS, 1983a). One of the reasons for this shift may be that when teachers have difficulty getting instructional software of adequate quality, rather than abandon the use of micros they place higher priority on activities for which the computer is clearly designed and for

which programs are available.

5. Implementing micros into the school

Neither schools nor curricula in their traditional form were designed to accommodate computers. Several problems confront attempts to introduce microcomputers into the educational life of the public schools.

5.1. Location, scheduling, and access

Most schools that have micros have only a few; it is unusual for a school to have enough to provide one for each student in a class of normal size. With such a low ratio of equipment to students, each student can be scheduled to use a machine for only a few minutes each week or, alternatively, only a few students in the school can have access to machines.

The physical location and configuration of equipment strongly influence both access and type of student use in many schools. Four patterns appear in reports from a study of two counties in southern California (Computer Use Study Group, 1983) and other reports (Williams & Williams, 1984) and personal interviews with teachers.

5.1.1. Computer labs

Some schools that can acquire several machines establish computer labs where the micros are installed. The lab may be installed in a room of its own, placed in a mathematics classroom, or set up as part of a media center. Classes are then rotated through the lab for, perhaps, one period of about 40 minutes each week or every other week, depending on the ratio of classes to available machines. In some schools, classes are divided and only

half the class goes to the computer lab at one time. This gives the teacher an opportunity to work for a time with a smaller class, but requires additional adult supervision.

5.1.2. Assignment to special programs

In some districts, the conditions of funding or an administrative decision allocates computers to a special group of classes that serve gifted students, low-achieving students, or some other identifiable category. In this pattern, machines may be distributed among several classrooms. This arrangement tends to restrict the number of different students who use the machines and limit the range of instructional activities. If the special program is for low achieving students, it invites drill-and-practice use. If it is for gifted students, there are more student-initiated activities, including programming and non-programming advanced applications--e.g., graphics, telecommunicating, and word processing.

5.1.3. Computers on wheels

Schools with too few machines to justify establishing a lab sometimes put micros on carts or tables with wheels and move the machines from class to class. This pattern combines the first two: machines may be available in a lab configuration for part of the day or week, then assigned to classes at other times. It offers flexibility and makes the machines more accessible to a larger number of students. However, this solution is often seen as less convenient for the teachers involved than a lab with more ample software and hardware resources. It requires the teacher to shift from one mode of instruction to another and to adapt to the machine quickly; there is not much time for the teacher to

familiarize herself with the equipment, load programs, and position the screen for viewing. In addition, machines are more vulnerable to damage, and staff and/or student time is needed to move and set up equipment.

5.1.4. Mobile labs

In some districts, the problem of access to micros is handled by creating a mobile computer laboratory. A bus is equipped with 20 to 30 micros and taken to a school to be used as a mobile classroom for a designated period of time--a week, a month, or a semester. A mobile lab used in this way offers infrequent or limited access to machines. Schools see this arrangement as a temporary adjustment to scarce resources.

5.2. Integrating micros into the curriculum

The versatility of the computer offers many opportunities for introducing computer-based material into the instructional program. Where computer science (i.e., programming, instruction about hardware) is taught as a subject and machines are acquired for a lab, instruction is roughly comparable to instruction in other laboratory courses--science, art, and music. The instructor remains in the classroom, students come for instruction and use the lab after or before school hours. The instructor or the students may organize a club to give students opportunity to carry out projects and pursue more specialized interests outside of regular school hours.

In some schools with a central computer lab, classes are rotated through the lab for drill-and-practice activities in mathematics, language arts, social studies, or for special non-

programming applications--word processing, using spreadsheets, and graphics. Sometimes the classroom teacher is expected to accompany the class to the lab and conduct the session. In either case, some accommodation is needed; the computer science instructor has limited knowledge of the needs of individual students and may not be thoroughly familiar with the material being taught or with the progress of the class. The classroom teacher, on the other hand, has less experience dealing with the equipment and must spend additional time in preparation in order to conduct the sessions smoothly and effectively.

5.3. Multi-use applications

Several schools have developed programs that de-emphasize drill-and-practice and programming, concentrating instead on helping students acquire productivity skills that will have more general application. One school in southern California uses the machines to help students develop these productivity skills that are then used in several classes. Word processing may be used in social studies and language arts, as well as in science or even mathematics. A computer linked to a bibliographic data base can be used to prepare research reports. Skill in graphics may also be applied to coursework in art, science, and mathematics. In another school, students use micros in the administration of student body activities--fees, check writing, accounting, financial statements and other functions once done by paper-and-pen accounting procedures. The concept underlying these uses of micros is that students will gain most by developing skills that can be used in a more versatile way. This approach requires that a number of machines be at the disposal of students; considerable practice is

required to develop adequate skill to use these tools in an efficient manner.

5.4. Diversity in student and teacher experience

Since any use of micros requires a minimal competence in operating the equipment, and increasing skills are required as more complex software or programming is used, most classes will have students who possess a wide range of experience and skill. Although wide variations of skill or knowledge pose problems for any teacher, such diversity may be especially troubling in working with computers. More individual instruction may be called for; students without experience may miss a crucial step--loading the program or saving the essay or homework--and become frustrated or bored. Some teachers deal with this problem by encouraging peer tutoring and assistance. One school issues "computer cards" for students who demonstrate a given level of competence (Williams & Williams, 1984). This card gives these students access to the computer lab after school and qualifies them to tutor other students or assist in the lab. About a third of the 270 students in the school have qualified for such cards.

5.5. Factors influencing implementation

Some aspects of implementation appear to be linked to the procedures through which micros are acquired and who it is in the school who regulates their use. For example, in elementary schools where the first micro was acquired by a group of teachers rather than by a single enthusiast, the use of computers is spread more evenly across students (43% have some contact during an average week), the machines are in use for more hours of the week,

and their use is spread across a wider variety of applications. In contrast, where the micro was introduced by a single teacher or by the administrator acting alone, fewer students (15%) use the micro during any given week, and machines are used to teach programming to above-average students (CSOS, 1984). The source of funding for micros is also related to their use. A contrast appears between schools where the micros were obtained from funds available to the principal and those where PTA contributions and other fund-raising activities supported the purchase. Where the funds come from more general participation, the equipment is used more often and by more students. In these schools, computer programming is more likely to be emphasized. This pattern appears more clearly at the elementary than the secondary school level (CSOS, 1984).

Examples of districts where the instructional use of micros has become widespread suggest that several conditions facilitate the use of new technologies. In one instance, the district had a history of encouraging innovation and revisions of the curriculum. Curriculum review and modification was an accepted part of the activities of the faculty. Implementation began when a single teacher became intrigued with the instructional potential of computers. Her suggestion that she use micros in her class was accepted as another new idea that the faculty was typically encouraged to develop.

As other teachers became interested, three additional conditions expanded the use of micros. First, parents became interested and raised funds to purchase additional machines, and local corporations made donations of micros. Second, the

superintendent supported the new project and publicly expressed his interest. Third, a staff development (district operated teacher training) program was already well established and training in using micros for instruction fitted easily into an existing structure.

5.6. The cycle of implementation

The experienced teacher who successfully integrates microcomputers into the classroom appears to progress gradually through several stages. Such teachers have already established their competence; they are accustomed to a given curriculum and have adopted an effective instructional style. At this early stage of the educational use of new technologies, there are not many models of how micros can be adapted for classroom use, and many teachers are cautious in their initial attempts to use this equipment. Computer phobia is a genuine experience for some teachers (Southeastern Regional Council, 1983; Townsend & Hale, 1981). In addition, many teachers have students in their classes who have considerable skill in operating microcomputers. Indeed, this has created a new role of "student expert" (Sheingold, Kane, & Enderweit, 1983). This reversal of roles is uncomfortable for many teachers, and some find it easier to avoid dealing with computers altogether.

In some districts where micros are widely used, teachers appear to go through several steps in developing competence in using computers in their classes. The first stage begins with a recognition that micros can be used to fit existing instructional needs--e.g., help students develop routine skills. The teacher

must also feel comfortable about using the machine. The first step is often a drill-and-practice program that can easily be used to supplement the regular assignments. This creates little disruption for the teacher and requires little time in preparation or in reorganizing the curriculum. Using drill-and-practice programs also gives the teacher time to learn to use the machine.

If this supplementary use of micros goes well, with little disruption of the normal teaching functions and with a positive response from students, the teacher may then be ready to use more complex programs--e.g., simulations--and begin to relate them more directly to the curriculum. If this second step is successful, the teacher may try software that is more extensive, perhaps a series that can be integrated into the curriculum. As teachers become accustomed to using the technology for relatively simple tasks, they may seek additional training. This may lead to attempts to develop software for the class or select software to serve as a unit in the curriculum, giving all students in the class an opportunity to use the equipment.

6. Impact on functions and roles

Because computers are instructional tools that can replace existing functions and are also a topic of instruction, they have a potentially significant impact on the roles and functions of faculty. In any given school, however, the impact varies with the pattern and extent of use.

6.1. Computer science and programming

The teachers involved in teaching computer science experience the most drastic changes in roles. Most of these faculty are teaching programming and information about computer hardware--

topics that were not covered in the courses they previously taught. For the most part, it was experienced teachers that took on these new teaching tasks; the districts did not hire specialists, but helped faculty members themselves specialize in these new areas.

The ease with which this transition is made depends on a number of factors--support from administrative officers, additional time allocated for retraining, availability of equipment and space, and the status that is associated with competence in computer technology. In many cases, a considerable part of the teacher's interaction with students revolves around computers and programming; they find themselves associated with new colleagues and professional groups, taking courses and workshops, and becoming part of communications networks to share information with other educators.

These teachers also become, de facto, resource persons in their schools and districts. In many places, they offer workshops for other teachers and sometimes for parents. They may organize and direct a computer lab, taking responsibility for maintenance and security of equipment, for selecting machines, making recommendations to the school or district about purchases of software and hardware, and serving on advisory committees and groups to help formulate policy that touches educational uses of computers. They are likely to find themselves involved in regional conventions, taking part in symposia or in demonstrations of programs they have selected, adapted or developed for use in a class in their school.

Typically, these additional duties do not involve additional compensation except that district or school funds are available to cover out-of-pocket expenses or travel to a convention. In many cases, they use their own funds to attend classes or meetings, purchase equipment and software. They may also become involved in raising funds for purchases of computers, preparing proposals to present to a foundation or to the district, state or federal government. These new faculty roles are not required of teachers. Most often, they participate because of their enthusiasm for working with micros and a belief that their students will benefit from contact with new information technologies.

6.2. Instruction in productivity skills

Teachers who help their students acquire skill in non-programming applications--e.g., word processing, music, networking, access to data bases, graphics--experience changes in their roles that parallel those of instructors in computer science. Indeed, the instructor of courses in computer programming and literacy may be responsible for training in advanced applications. In other instances, however, teachers may acquire skill with productivity programs without learning to program. Teachers in some schools help children develop word processing skills at the beginning of their semester or school term so that they may use the micro in doing assignments in the subject they expect to teach. This may require approval and support of administrative officers or committees since it is a reallocation of instructional time to developing productivity skills. These teachers may believe that these skills will motivate students to gain more from the class, or they may also

believe that the skills developed are worthwhile in their own right.

The teacher in charge of the computer lab may share the task of teaching productivity skills. In some schools, teaching word processing and related skills is part of the curriculum; teachers in the upper grades may reasonably assume that most students have acquired competence with applications packages. Many teachers believe that they must also acquire these skills in order to help their students use such applications programs effectively. To gain this sort of competence, they attend workshops, courses, and professional activities.

6.3. Using computers as instructional tools

In most districts, only a few teachers use micros extensively in teaching the traditional subjects. A larger number involve their classes in limited instructional use of micros--either through drill-and-practice, simulations, or occasionally some interactive lessons prepared by the teacher for the class. Teachers who use instructional software in traditional subject areas may acquire diskettes with programs to teach a specific topic, or they may obtain courseware that offers a series of sequential lessons covering several weeks or a semester. They may also work with the coordinator of the computer lab--usually another faculty member--to help the coordinator prepare lessons to be used on a particular topic when the class has its turn in the computer lab. This sort of collaborative effort is not new--many schools use team teaching--but it may involve cooperation between teachers of quite different subjects. The computer coordinator

who once taught mathematics may now help prepare lessons for language arts or history. The new technology often encourages new forms of cooperation across subject matter areas.

Teachers who use micros for instruction may also become active in workshops, conventions, professional associations, and networking with other teachers. They may participate in committees to evaluate software, work alone or with others to develop software, help prepare instructional modules to help other teachers acquire skills with the machines, offer workshops to other teachers, and act as resource persons for schools in the area as well as their own.

7. Training

7.1. Teachers of computer science and literacy

Teachers who plan to use the micros in a more interactive way, either by teaching programming or technical skills dealing with computer hardware, need much more training than teachers who use micros as a supplement to regular instruction. The training acquired obviously must be suited to the instruction they intend to offer. If they plan to teach PASCAL, some kind of extended formal training is virtually required; several weeks of relatively intensive work may be involved. The need for training is described in the Bulletin of the National Association of Secondary School Principals (NASSP) (cited in Levin, 1983).

> We found that 80 hours of hands-on experience were insufficient to learn more than basic programming skills... Sending (teachers) back to college or having the local university hold courses after school in the district is not the answer. Much information and knowledge is lost when a

computer course is attended once a week for three months. Also, teachers cannot get enough hands-on experience by attending courses after school or in the evenings. One or two-day inservice programs are not the answer. Our experience shows that if a program is to be successful, the participants need to be able to work the computer for from two to four hours at a time. Based on our success, we highly recommend two-week summer camp sessions lasting seven hours per day...

The demand for intensive training to prepare teachers who will become subject specialists in computer programming and related skills led to the appointment of a working group of the Association of Computing Machinery, selected by the Education Board of the Subcommittee on Elementary and Secondary Education. The ACM has been actively involved in educational applications of computers for several years, and the appointment of this Task Force is consistent with the continuing involvement of this professional organization. The goal of this group is to develop standards for teacher certification. James Poirot, of North Texas State University, chairs the group. In a preliminary draft of a report, he points out that other subject matter specialists have courses in elementary and secondary school, and in college, take courses in teaching the subject material, and pass tests that are prerequisite to earning teaching credentials in the subject. Several thousand teachers are now offering instruction in programming and computer literacy and the number is growing. There is a need to provide adequate training for these teachers.

According to Professor Poiret, it appears that the Task Force report will include a required list of courses along these lines:

1. Computer programming I

   High level programming language, skill in problem solving methods, algorithm development, ability to design code, debug, and document programs, top-down design and structured programming methods.

2. Computer programming II

   Additional skill in programming design, debugging and testing, especially for larger programs, algorithmic analysis, string processing, recursion, internal search, sort methods, and simple data structures, and documentation.

3. Introduction to computer systems

   Provide basic concepts of computer systems; elementary computer architecture, and assembly language.

4. Organization of programming languages

   Understanding of organization of programming languages especially the run-time behavior of programs; formal study of programming language specification and analysis; additional competence in problem solution and programming skills.

5. Computers in education and society

   To introduce the use of computers in education, to analyze problems associated with educational computing--software evaluation, hardware evaluation, and administrative applications of computing, to use programming languages appropriate for educational

purposes.

6. Methods for teaching computer science

(Specifics to be supplied).

The Task Force may recommend these additional courses as electives: 1) Computers in society, 2) Computer assisted instruction, 3) Introduction to file processing, 4) Data structures and algorithm analysis, and 5) Introduction to computer organization.

The Task Force assumes that if BASIC is taught, it will include skill in building control structures out of the common control statements, the technique of top-down, modular design and handling problems in program logic by the use of formal control structures for loops and branches. LOGO is recommended as part of the sequence. PASCAL is seen as a programming necessity at the present time. The importance of PASCAL is heightened by the recent development of a test for competence in PASCAL that may be taken by high school students who wish to qualify for advanced placement credit in college.

The recommendations of this group will be considered at a national conference in the spring of 1984. If any action is taken, it will be advisory only; faculty involved in teacher training in the various states, together with the appropriate authorities at the state level, will eventually make decisions about their own curricula. The recommendations of this task force are likely to carry considerable weight, however, particularly in states where there is already serious consideration of training programs for teachers of computer literacy and/or science courses.

7.2. Training for productivity skills and instruction

Teachers who expect to instruct students in productivity skills also need considerable technical training. In some instances, particularly graphics, music, and use of audio or videotape, some programming skill may be required, or will be helpful in creating training modules or assignments. The degree of training needed varies with the complexity of the tasks that the teachers want to cover. Some word processing programs, for example, The Bank Street Writer, may be relatively easy to master but have limited capabilities; some other programs demand both training and considerable experience and practice, but offer sophisticated options for text format and design.

7.3. Training programs and arrangements

The need for training is one of the major contemporary concerns in educational computing. The most significant problem, perhaps, is that microcomputers were introduced into a profession that was untrained in their use. Coming into the schools through a grass-roots movement, training needs were initially not organized in a systematic way. Teachers who wanted to acquire skills followed a chain of opportunities that were fortuitous or developed by determination and effort. Tutoring by friends, by students, by colleagues or by sales representatives was a common source of competence.

As the technology became more widely accepted and its uses began to be more distinctly defined, training programs took on more consistent shape. In California, at the present time, for example, training is offered through a system of Teacher Education

and Computer Centers (TECC). Modules for training trainers of teachers are also prepared and distributed through the Centers. In one region, the Center works with the Coordinator of Computer Education of the County to provide training modules for other Centers in the State. Training programs are also offered by extension services (evening, weekend sessions) of the University of California; private universities offer summer courses in PASCAL and workshops in programming and productivity software packages. Courses in programming, including assembly languages, computer hardware and electrical principles applicable to computing, computing for handicapped students or preschoolers are offered by community colleges--two year post-secondary schools established some years ago as part of the California system of higher education. Some districts offer their own workshops and courses.

At the present time, the distinctions we make between machine-dependent and other types of computer use are not incorporated into training programs in a systematic way. The field is changing too rapidly for this sort of consolidation. If it is true, as we suggest, that training in productivity skills will increase in importance and the demand for programming decline, training programs will be modified. The current pattern of staff training and development seems to be an individual course oriented around a specific topic, e.g., Introducing the Apple, LOGO for Beginners, Introduction to PASCAL, Word Processing--From the Beginning. Where the school district organizes and operates its own training program, the offerings are more sequential and comprehensive in scope. We will describe the training program of

one school district in more detail in the last section of this chapter.

The need for inservice training comes in part from changes in technology. The instructional staff must decide what level of obsolescence they can tolerate within the limits of their economic resources. At some point in the future, however, the level of sophistication of hardware will reach an acceptable degree of stability and obsolescence may present less serious problems. This is not likely to happen in the near future, even with hardware where educationally important advances are appearing (for example, some limited natural language recognition capabilities and videodisc may soon be technically adequate and economically accessible for use in schools).

Such rapid change suggests that there will be a lengthy period of transition during which training for teachers who are new users will be offered along with continuing or periodic inservice training for teachers who have already acquired competence. Such continual training will probably increasingly be incorporated into administrative planning, with allocation of sufficient time and resources on a continuing staff development basis. Some school districts may find it feasible to develop a center for inservice updating for teachers, thus providing their own training resources. In the future, such updating may be available on-line.

Some funds for training also come from computer corporations. Apple, Atari, and Tandy (Radio Shack) have supported developmental and training activities. IBM established a program in 1983 to

link 84 secondary schools in three states (California, Florida, and New York) to 12 teacher training institutes. Trainers were brought to a national center and provided with two weeks of instruction by the Educational Testing Service (ETS) which coordinates the entire project. These trainers then offered a four-to-six week training program during the summer for three-to-five people from each of the seven high schools in each area.

The summer training sessions are illustrated by one site in California. The training team was composed of two specialists who had been to the training institute at ETS plus two teachers and a student with experience with computers. This group developed several principles to guide the summer institute (Wagner, 1983):

1. Lecture or large group demonstration could not be the primary mode of instruction.
2. Each of the seven school teams was to be cohesive.
3. The computer experience of the entire class was to be utilized.
4. Extensive hands-on experience was essential.
5. Teachers were to be given time to develop their own ideas.
6. Teachers from each school should continue to work together after they returned to their own schools.
7. Newcomers to the field needed a general introduction to resources they could use.

After two weeks in class, teachers took computers home for two weeks of experience, then returned for another two weeks of summer session. The topics and activities for the four-week training session covered a wide range of topics, including productivity programs, instructional programs, and some limited

Table 1

Curriculum of ETS/IBM Summer Training Program

Week 1

Orientation to the computer
Introduction to disk operating system
Word processing -- Easy Writer
Exploring the PC within the program INSTRUCTOR
Project: Use Easy Writer to produce three questions based on content of INSTRUCTOR
Using the program QUESTION
Group project: Use QUESTION in your classrooms
Introduction to PFS:FILE
Demonstration of PFS:REPORT and PFS:GRAPH

Week 2

DELTA DRAWING --individual instruction
VisiCalc -- group demonstration
BASIC -- group discussion and the BASIC PRIMER
Reports: Preliminary plans for computer use

Week 3

Plan projects
Presentation: LOGO in the school
Presentation: Setting up and using a computer lab

Week 4

Finding, selecting, buying and using software
Telecommunications in general; demonstration of SOURCE
Setting up an on-going network
Presentation: Designing in-service training
Presentation: Ethical considerations in computer use

Computer Faire: Examples of projects on display:

A BASIC program to keep grades on the PC
Using TYPING TUTOR, INSTRUCTOR, & BASIC PRIMER in the classroom
Computer managed instruction: grades, tests, dittos, etc.
Applications in math and science
Advanced topics: PASCAL, graphics, music.
Applications in the business curriculum
Using QUESTION and sharing files

experience with programming. Activities for the group or for subgroups included developing a program for introducing computers to their own home schools, preparing curriculum materials, applying software programs to administrative and instructional uses (Wagner, 1983).

The ETS/IBM training program includes electronic mail service among the 84 schools, a newsletter that describes activities in various schools, and an Application of the Month Award to teachers who have developed imaginative uses of micros in classes. Teachers from programs of this kind then become trainers, informally or in more structured classes, for other teachers in their own schools or districts.

8. Software

Software, along with staff training, may be the key to the growth of instructional uses of micros. We consider three issues in this section: 1) the quality of programs available on the market; 2) the role of teachers in producing their own instructional programs; and 3) evaluation and purchase of software.

8.1. Quality of educational software

Educational software is commonly regarded as inferior. Although some good quality programs are available, lack of software is still the most serious hindrance to effective use of computers in schools in the United States.

The quality of instructional software is linked, of course, to economic factors. It is usually more profitable for firms to produce software for the business community than for the schools.

Some publishers of textbooks find that producing courseware is less profitable than publishing textbooks has been in the past, in part because of the ease with which it can be copied, and are reluctant to commit investments to developing computer-based materials. However, there are indications that major corporations not traditionally involved in educational publishing may enter this field. There is also a possibility of collaboration between governmental agencies and corporations to support the intensive developmental work that is required to produce sophisticated interactive educational programs.

There are other difficulties for teachers who attempt to find suitable software. Since some of the most useful programs are used by individual students for interactive, individualized instruction, the level of competence of the student must match reasonably well the software material to avoid boredom or frustration. This requires either (1) a highly sophisticated program, run on a computer with enough memory to monitor student progress and use this information in presenting subsequent lessons, or 2) a considerable variety of smaller programs from which teachers or students can select to fit their level of competence. It is difficult and expensive to produce software that is appropriately tailored to the needs of students from a range of age, socioeconomic, and ability levels.

8.2. Teachers as designers and producers of software

Although some professionals believe that sufficient adequate software can only be produced by teams of specialists, including a teacher experienced in the relevant subject, teachers do actively, and effectively produce materials for use in their classes. The

IBM/ETS Secondary School Computer Education Program, described earlier, fosters this kind of developmental activity. For example, a biology teacher has put the chemical structure of each of the bases for DNA into text files so that students can `chain` base pairs together to make long chain molecules. Another teacher has started a PFS:FILE for his earth science students that is a catalog of common minerals, including properties of luster, texture, cleavage, hardness, color, crystal habit, smell, etc. This base is to be used by students to identify specific samples that are brought into the classroom.

These are two examples of the kind of software that teachers are developing for their own purposes. In some areas, facilities are available for exchanging programs produced by teachers.

8.3. Selection and evaluation of software

The degree of difficulty in selecting suitable software differs from one type of use to another. Teachers who offer instruction in BASIC or some other programming language deal with a language structure that is already in place; their task is to select an instructional technique for presenting programming rules and conventions. Providing instruction in word processing or accounting is roughly comparable; although there are variations in the material that different vendors offer, the central elements of the language or program are similar once the programming language has been selected or the particular application package (e.g., word processing, spreadsheets) has been chosen.

The procedure for selecting educational software seems to present most problems with materials to be used for supplementary

and drill-and-practice instruction. In some schools, this choice is made by the teacher acting alone. In other situations, there may be a committee designated to make the final selection. In Minnesota, software purchases are restricted to a list approved by a software library and resource center established within the State Department of Education operated in collaboration with the Minnesota Education Computing Consortium (MECC). Purchases of software with state funds are restricted to a list of software approved by the State. Membership in MECC is open to schools and districts outside of Minnesota. There is a growing trend toward more centralized procedures and standards in purchases of educational software, but there is still considerable diversity in practice.

Selecting educational courseware requires considerable time for the teacher to view programs and, ideally, to see students using them. Some districts have established technology centers where a wide range of programs is offered for viewing and where comments from teachers who have used the programs are available. Organizations of computer-using teachers may establish electronic bulletin boards to provide opportunity for exchanging information about programs. Local, regional and national conventions are also sources of evaluations of software. An evaluation service (EPIE) is available through a national consumers' research organization and an educational association. This group provides member districts with systematic reviews of software and hardware. It also offers training to teachers in evaluating software.

The major dimensions used by EPIE in its evaluation include a description of the configuration needed, curriculum objectives,

ratings of instructional design and of software design. Criteria used to make these ratings include user appropriateness, accuracy and fairness, clarity, graphics, audio, user control, feedback, branching, tests, records/management, and documentation/teachers' guide materials.

In California, a clearinghouse for evaluating educational software is part of the Microcomputer Center located in the San Mateo County Office of Education near San Francisco. This clearinghouse provides an exchange service, at cost, and may help revise and update programs submitted by teachers. It also evaluates software for the 15 Teacher Education and Computer Centers (TECC) located throughout the State of California. Publications prepared for teachers often include tips, examples of lessons, and other resources for teachers to use in preparing their own computer-based materials.

The director of the clearinghouse activities also convenes an annual Forum to evaluate educational software. This conference brings together agencies that are active in software assessment (e.g., Microsift, EPIE, MECC) and individuals from professional organizations (e.g., Computer Using Educators) and some training programs (e.g., Moursunds' program at the University of Oregon).

The members of the conference review software, identifying what they consider to be the best generally available materials. New programs are compared with existing software. The recommendations of this group are published as Software Preview Guide, which is generally available.

8.4. Summary

In the short-term, greatest use of computers will almost certainly continue to be found in areas for which the computer is easily adapted: mathematics, science, language arts (including spelling, phonics, sight-word development, vocabulary, alphabetizing, letter-writing, reading), problem-solving (e.g., through simulations), science, foreign language, and business. Whether it will be used in other areas depends on either the development of easily used software with adequate instructional promise or on training teachers to be competent in programming the computer for their own instructional purposes.

It is not possible now to predict whether the micros will be used to a significant degree in these other subjects. It is relevant, however, that a recent convention of the National Council for the Social Studies offered a single preconvention instructional program in the use of computers in social studies. Instructional space was provided for 50 teachers. However, more than 2,000 teachers applied for this training session. This level of interest does not in itself mean that micros will be adapted for use in social studies, but the desire for training may indicate a significant trend.

9. Examples of approaches to computer use

Two examples illustrate different approaches to the utilization of computers as an educational resource. These institutions are unique in that they are located in California's Silicon Valley, the home of many high-tech industries, and are examples of innovative programs developed in the best of environments. Cupertino Union School District is made up of twenty elementary and four junior high schools serving six

municipalities with approximately 11,000 students. The Institute for Computer Technology is a joint venture of education and industry that is described as "an educational institution dedicated to providing students, teachers, and community members with opportunities for career development in an increasingly technological society."

9.1. Cupertino Union School District

9.1.1. History

In 1977, Apple Computer Company showed a prototype of its Apple II microcomputer to Bobby Goodson, a mathematics teacher, and to William Zachmeier, the Associate Superintendent of Schools. They were intrigued by its potential educational applications and succeeded in obtaining funds that allowed Mrs. Goodson to spend two years working with students and teachers investigating student interaction with computers in an effort to develop a computer literacy program for the district. Inservice training was offered to interested teachers. The major focus was on the use of computers to enhance student learning and creativity rather than to teach programming skills.

By 1981, a computer literacy program for the district had been developed, and the School Board approved the necessary funds for a computer lab in each of the four junior high schools and for a lab or computer cluster in 10 of the 20 elementary schools. In order to request support for a cluster of micros, each school was asked to submit a proposal outlining plans for inservice training and responsibility for program management, equipment, and software acquisition and storage.

9.1.2. Funding

A proposal for the use of microcomputers in a junior high school mathematics project was approved by the State of California and these (Title IV-C) funds were used to support Bobby Goodson's first two years as Coordinator of Computer Programs. Initially, Title IV-B funds were used to buy about 35 microcomputers. Monies from state grants, funds for gifted students, and parent-teacher association contributions were used for the purchase of additional hardware. The community has supported the computer literacy program from its inception, and parents have been involved in both fund-raising and assisting with micros in the schools.

In 1981 the School Board approved funds for microcomputers to implement a district-wide computer literacy program and support teacher, administrator, and parent training through the District's existing staff development program.

9.1.3. Hardware and software selection

Originally, the District had planned to purchase Apple computers. However, a lower bid was submitted by Atari Corporation, resulting in a decision to purchase some of each brand. District personnel believe that the availability of different brands of computers is advantageous because of the special capabilities of each. There is also less tendency for students' skills to be confined to a particular machine.

A District task force composed of the Computer Coordinator, the Director of Media Services, the Curriculum Coordinator, and the Junior High School Computer Lab Coordinator is responsible for previewing software. Items that appear to be useful are

tested in the classroom before they are listed in an inventory of courseware that may be purchased with District funds. Computer literacy materials are now being developed for the elementary schools.

9.1.4. Programs

Microcomputers are used in the classroom to supplement instruction. Programming is taught in junior high schools through the use of graphics, music, and animation. The micros also have managerial applications for faculty and staff--e.g., to keep student records and grades. In addition, the computer is used with the special education classes and in a computer camp during the summer.

A kindergarten-8th grade literacy curriculum was developed in 1981, a revision was prepared in 1982, and a second revision in 1984. The curriculum recognizes that teacher expertise plays an important role in students' learning. The curriculum is a flexible document with suggested grade levels for skills to be introduced, expanded, or reinforced. Schools can follow the specific grade levels suggested or the grade blocks (K-3, 4-6, 7-8) to guide their instructional plan.

9.1.5. Teacher training

Inservice courses are available through the District's staff development program. At the request of individual schools, school-based staff development programs are offered to meet specific needs. In addition, summer training is available in a computer lab setting where teachers learn by working with students. Teachers may also borrow school microcomputers to use

at home. Classes are usually taught after school hours and some courses that require large blocks of time are given on Saturdays. District teachers serve as instructors. Presentations by outside experts were sometimes regarded as too technical, and training by teachers who were aware of training needs and computer uses in the classroom was preferred.

Teachers progress through small, non-threatening modules that are designed to cover topics from computer awareness to software for classroom use to computer programming. Hands-on experience is an important component of all training.

In order to provide additional support for teachers, a lead teacher network was organized in the District. One teacher from each school represents the program whose purpose is to assist teachers just beginning to use computers as well as to share experiences across schools. Separate training has also been designed for school principals. These courses concentrate on questions of administration, curriculum, and managerial uses of the computer. Parents may also be trained in a 10-hour sequence on computer awareness and how computers are used in the Cupertino curriculum; these parents can then work in the schools assisting in the computer literacy program.

9.2. Institute of Computer Technology

9.2.1. History

The Institute of Computer Technology (ICT) was organized in 1982 under a joint powers agreement by the Fremont Union High School District, Los Gatos Joint Union High School District, and the Sunnyvale School District. Initial funding of $100,000 was received from the State of California. The objectives of the ICT

are:

To provide computer technology courses--ICT will develop and present computer-related courses of study that enhance career opportunities and facilitate access to current technology both for students and for other interested community members. The institute will maintain continuous communication and involvement with industry to ascertain current educational needs. As a supplement to local school-system offerings, ICT will provide advanced and/or experimental programs.

To provide a framework for the growth of computer education--ICT will assist elementary and secondary school systems in developing computer technology programs. By producing more highly qualified and motivated students, ICT will encourage institutions of higher education to enrich their course offerings.

To serve as an innovator in education--ICT will employ a variety of teaching strategies. It will seek ways of enhancing the teaching of traditional subject matter by experimenting with subject groupings and new teaching methods made possible by computer technology. ICT will provide a laboratory for testing and refining new ideas and will develop programs that can be transferred to all levels of public education.

To foster cooperation between industry and education--ICT will provide opportunities for school teachers and industry representatives to teach and work together, thus supporting

an exchange of ideas and expertise between the two groups.

Staff members consulted with electronics firms from the surrounding area, e.g., AMD, Inc., Amdahl, Apple, Applied Technology, Fairchild, Four Phase, GE, GTE/Sylvania, Hewlett-Packard, IBM, Lockheed, Pacific Telephone, and Westinghouse, as well as the Santa Clara County Manufacturing Group and Industry-Education Council. Feasibility studies were conducted in cooperation with organizations such as Consulting Exchange, SRI International, and American Institutes for Research.

A seven-member board of directors was established to administer the Institute. Four industry members are elected on staggered two-year cycles, in addition to three school district members. There are also two full-time directors of the Institute, one of whom is an executive on loan from IBM Corporation.

In September 1982, legislation was passed making ICT a public school, and classes were started in January of 1983. Legislation is pending that will provide state funding for three years to allow the ICT to serve as a model and to disseminate information regarding its foundation and management.

9.2.2. Funding

After the initial support, additional state funding has been based on average daily attendance (roughly $250,000 in 1983). Approximately $800,000 has been contributed by high-tech industries, commercial firms, foundations, community members, and federal agencies in the form of financial contributions, loaned personnel, hardware (including 60-70 micros), software and supplies. The proportion of industry support to state funding is expected to be 3-to-1 by the end of 1984. Hardware and software

acquisition has been dependent on donations from the various firms involved in the venture.

9.2.3. Programs

The Institute is located at Saratoga High School in the Los Gatos District and at De Anza Elementary School in the Sunnyvale District. Students in kindergarten through 12th grades and adults residing within the boundaries of the three school districts are eligible to attend ICT classes. Courses that are offered at the ICT are in the computer sciences, electronics, and other topics related to high-technology. In 1983, the pilot year, course offerings were selected on the basis of meeting specific student and private industry needs. These included: Introduction to BASIC, Introduction to LOGO, Using Computers, Computer Architecture and Assembly Language, Structured Program with PASCAL, Creative Problem-Solving, Computer Law, Data Entry Skills, Computerized Accounting, and VISICALC.

A new program for students who have withdrawn from high school before graduation began in January, 1984. Courses encompassed building computers and data processing. Additional plans for 1984 include advanced computer language courses (i.e., FORTRAN, COBOL), information systems courses (i.e., data base, data communications), programming techniques and problem solving, computer careers and applications, electronics and computer maintenance, programming development, group dynamics and team programming, and self-directed computer use.

Teacher training classes have also been conducted as well as computer classes for senior citizens (average age, about 70) who

are trained to work as teachers' aides.

9.3. Teacher training.

All instructors at ICT are paid on an hourly basis and teach only one or two courses. Many are full time employees in industry. The educational reform bill (State Bill 813), passed in July, 1983, allows schools to hire teacher trainees who have college degrees and passing scores in skill and subject matter examinations, provided that the trainees have the supervision of a mentor teacher and an individual training plan.

10. Summary

Several major features characterize the use of microcomputers in schools in the United States. There is enormous diversity, fostered by a degree of autonomy in educational agencies at the local level and the grass-roots nature of interest in educational uses of new technologies. Micros were brought into schools by enthusiastic teachers, groups of parents and students, and administrators; administrators have played a greater role in recent years. The use of micros in schools is more evenly spread among students where groups of teachers have been involved in acquiring machines and implementing their use. The number of micros in schools has continued to rise rapidly in both elementary and secondary schools.

Three general types of use are appearing. Micros are used to teach computer science/literacy; for instruction, including drill-and-practice; and to teach productivity skills--word processing, graphics, use of spreadsheets, applications to music, accessing knowledge data bases, networking, and telecommunication. Schools

differ greatly in their tendency to emphasize one or another of these uses; there are some indications of increasing use of machines to teach productivity skills.

Most schools have very few machines and these are often arranged in one of four patterns: located in a computer lab, installed in a mobile trailer/classroom that is moved from school to school, assigned to special types of students, or put on tables with wheels and moved from classroom to classroom. Scheduling students' time on machines generally follows the physical arrangements adopted by schools: classes may be rotated through a lab, machines brought into a classroom, or a combination of patterns. Several brands of machines are used; many were donated or sold at deep discounts by computer firms.

The new technology affects most strongly those teachers who change from traditional subjects to instructing in computer science or literacy. This shift usually follows the inclination of the teacher, with support and approval from administrative officials. Such teachers may coordinate the computer lab, act as resource persons for the district, help train other teachers and staff, and assume administrative functions on committees to establish policy, select software, and prepare curricula. Teachers who help students acquire productivity skills may also teach computer science courses; if not, their roles may change less drastically. Teachers who use machines for instructional purposes, especially drill-and-practice, experience fewer changes in their roles. Training patterns are emerging to follow generally the patterns of use. Intensive curricula are being proposed for teachers of computer science/literacy, with attempts

by professional organizations to develop standards for certification. Much of the training acquired at present is on initiative of individual teachers through courses, workshops, conventions, colleagues, and publications. Some districts have extensive staff development programs which become effective vehicles for training. Some training programs have been established by corporate donations.

A major barrier to more extensive use of micros in instruction is a lack of good quality software for use in traditional subject areas. Publishing companies find courseware less attractive economically than publishing textbooks has been in the past; much of the software available does not take advantage of the versatility, speed, memory, and interactive capabilities of computers. Some teachers develop their own materials or adapt commercially available programs for their own uses. Some see benefit in teaching word processing and advanced non-programming applications that students can use in a variety of courses.

There are few evaluations of the effects of new technologies on schools on either student achievement or on the organizational life of the school. Considerable interest is shown in such information. However, the differences among schools in patterns of use and emphasis on the functions to be served by micros makes generalizations untrustworthy at the present time.

The growth of instructional uses of micros in the schools appears to be closely linked to three considerations: 1) providing training programs to help teachers develop proficiency in productivity skills and utility programs and in instructional

uses of micros; 2) external support for developing adequate educational courseware for traditional subject areas; and 3) acquiring enough machines to give more students more time on a regular basis. The widespread use of computers in the society will itself encourage schools to adapt this technology for instruction. As an increasing number of students gain competence with micros in school and at home, they and their parents will expect the schools to acquire and use the new information technologies as a normal part of the educational process.

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